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Effect of Organic Acid Blend on Carcass Yield, Nutrient Digestibility and Tibia Ash during Starter Phase of Broiler Chicks

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AS and Shahroom K designed the study. Sarzamin K conducted the research. NC analysed the data. MSK nad HM edited the paper.

Key words
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ABSTRACT

A total of 180 broiler was supplemented with organic acid (OA) at the rate of 0, (OA-0), 0.5 (OA-0.5), 1 (OA-1), 1.5 (OA-1.5) and 2 ml/l (OA-2) in drinking water during the starter period for 21 days. Feed intake was significantly (P<0.05) lower and weight gain and dressing percentage were significantly (P<0.05) higher in the OA-2 group, resultantly, the best feed conversion ratio (FCR) was recorded in the same group. Tibia dry matter, ash, calcium (Ca) and phosphorous (P) were significantly (P<0.05) higher in OA-2. On the other hand, fecal Ca and P decreased significantly (P<0.05) in OA-2. Mean dry matter and ash contents increased significantly (P<0.05) in OA-2, while crude protein, crude fibre, ether extract and metabolizable energy increased significantly (P<0.05) in OA-1.5 and OA-2. In conclusion, addition of OA in drinking water at the rate of 2 ml/L improved weight gain, feed efficiency, nutrient digestibility, and tibial mineralization of Ca and P in broiler.

INTRODUCTION

Birds are inevitably exposed to considerable stress under the modern system of poultry production (Khan *et al*., 2011, 2012a). The gastrointestinal tract of newly hatched chicks is immature and sterile. Development of GIT function and microflora occur as soon as the feed is ingested (Adams, 2004). Due to the concern of the antibiotic residues in meat, the use of antibiotics is banned as feed additives in routine in the recent years (Leeson, 2007; Abudabos *et al*., 2016; Alhidary *et al*., 2017; Zia ur Rehman *et al*., 2017). This leads to the use of chemical substances which are non antibiotic in nature (Khan *et al*., 2012b, c; Khan and Naz, 2013; Abudabos *et al*., 2018). Organic acids (OAs) are used as the best alternative, singly or in combination of many acids (Sultan *et al*., 2015; Rahman *et al*., 2017).

Short chain fatty acids (SCFAs) were amongst the OAs, judged as a good replacement for antibiotics (Hayat *et al*., 2014; Abudabos *et al*., 2017). One such SCFA is butyric acid, which has more antibacterial activity (Leeson, 2007; Khan *et al*., 2016). Butyrate obtained from the non starch polysaccharides fermentation is known as crucial for epithelial cells development, increase gut health and decrease occurrence of colon cancer in humans (Brons *et al*., 2002). However, in the caeca and intestines of young chicks, the level of SCFAs is quite low (van der Wielen, 2000). Some previous experiments showed positive effects of OAs on bone ash and mineral retention in pig (Jongbloed *et al*., 2000) and rainbow trout (Vielma and Lall, 1997). In laying hen's diet, the addition of OA showed a positive effect on quality of bones and eggshell (Świątkiewicz *et al*., 2010). In the feed industry, to improve feed hygiene, various OAs are used (Martin and Maris, 2005), when the pH of digesta is low, the digestive enzyme and phytase activity is improved, and gastrointestinal functions are beneficially affected (Jongbloed *et al*., 2000; Dibner and Buttin, 2002). Phosphorus, calcium and zinc retention was improved by citric acid in the tibia in broiler (Brenes *et al*., 2003; Islam *et al*., 2012). The gastric pH can be lowered by adding OA into the feed (Garrido *et al*., 2004) and the pH of the digesta can be reduced by OA (Maenz *et al*., 1999). The conversion of pepsinogen to pepsin is accelerated by low gastric pH, which enhances

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the rate of absorption of amino acid, minerals and protein (Youn *et al*., 2005). The objective of the present study is to find the effect of different levels of OA on the performance, digestibility and tibial strength of broiler during the starter period.

MATERIALS AND METHODS

The study was approved by the departmental committee on ethics and welfare of animals.

Experimental design

A total of 180 broiler birds (day old) was adapted for a period of one week and then divided into four groups designated as OA-0.5, OA-1, OA-1.5 and OA-2. Each group was further consisted of 3 replicates. The birds were fed with OA at the dose rate of 0, 0.5, 1, 1.5 and 2 ml/l in the group OA-0.5, OA-1, OA-1.5 and OA-2, respectively. The OA blend consisted of ortho phosphoric acid, formic acid and propionic acid. The feed comprised of maize, 60.7; soybean meal, 35.6; vegetable oil, 0.5; limestone, 1.4; dicalcium phosphate, 1.2; DL methionine, 0.15; salt, 0.4 and vitamin + trace mineral premix, 0.3. The calculated nutrient composition are protein 22% and poultry ME 2960 kcal/kg. Each kg of premix consisted: pyridoxine, 1 mg; folic acid, 0.4 mg; molybdenum, 0.32 mg; ethoxyquin, 25 mg; choline chloride, 60 mg; dl-α-tocopherol acetate, 4 mg; iodine, 0.2 mg; thiamine, 0.3 mg; Ca pantothenate, 3 mg; cyanocobalamin, 3 µg; biotin, 0.02 mg; Mn, 15 mg; Zn, 10 mg; iron, 4 mg; Cu, 1 mg; Co, 0.06 mg; Se, 0.02 mg; cholecalciferol, 0.018 mg; trans-retinol, 0.66 mg; menadione, 0.4 mg; riboflavin, 1.6 mg and niacin, 6 mg.

Performance traits

The estimation of the feed intake was done by providing a calculated amount of feed and weighed the daily feed refusal. Analysis of data was performed on a weekly basis. On a weekly basis, gain in body weight was calculated. On the first day of the week, the weight of the bird was calculated and then at the end of the week, the weight of the birds was measured to determine the gain in body weight. Feed conversion ratio (FCR) was calculated on a weekly basis and mortality was adjusted accordingly. The weight of gizzard, liver and heart was calculated as relative organ weight. From each replicate, two chicks were randomly selected which were first weighed and then slaughtered. Dressing percentage was determined by weighing the carcass.

Fecal collection

Specially constructed metabolic cages were provided for fecal collection. Six chicks were transferred for fecal collection from each replicate to the cages on day 17 of the experiment. Calculated amount of feed was provided till the last day of the trial in all the cages. Collection of feces was done on day 22. On a weekly basis, the weight of the chickens was taken. The trial was performed till the 22nd day.

Chemical analysis

Excreta samples were analyzed for nitrogen (Kjeldahl method; AOAC, 1990), CP (N × 6.25), dry matter (drying in oven at 103°C for 8 h), crude fibre (AOAC, 1990), ether extract, calcium, phosphorus (AOAC, 2000) and ash (Vogtmann *et al*., 1975). Metabolizable energy (ME) was determined with the help of bomb calorimeter as described by Sultan *et al*. (2015).

Measurements of tibia strength and ash content

From three chicks per group, the right tibial bone was taken. Cleaning of all the extra tissues was performed, and the tibia was placed in the refrigerator till analysis at 0°C. Weighing and drying of the tibia were done, followed by crushing and finally defattening for 48 h in refluxing ethyl ether in a Soxhlet apparatus. The tibia was dried in an oven in ceramic crucibles, and ashed at 550-600°C for 4-6 h. Expression of the ash content was done as a percentage of the fat-free and moisture-free tibia weight (Chung and Baker, 1990).

Table I.- Effect of OA on mean feed intake, weight gain, FCR and dressing percentage during starter phase.

Group	Feed intake (g)	Weight gain (g)	FCR (g/g)	Dressing percentage
Control	1063.18±5.51 ^{a}	578.31±4.63 ^{d}	1.72±0.006 ^{a}	59.28±0.21 ^{d}
OA-0.5	1047.71±3.84 ^{ab}	596.67±6.69 ^{cd}	1.71±0.011 ^{ab}	60.11±0.39 ^{c}
OA-1	1036.24±5.56 ^{bc}	606.33±7.68 ^{c}	1.69±0.014 ^{b}	60.45±0.55 ^{bc}
OA-1.5	1026.12±6.24 ^{c}	625.68±6.01 ^{b}	1.67±0.012 ^{c}	61.88±0.12 ^{b}
OA-2	1000.33±5.84 ^{d}	647.67±3.75 ^{a}	1.64±0.044 ^{d}	63.07±0.17 ^{a}
P-Value	0.0001	0.0001	0.0005	0.001

Mean values within a column differ significantly (P<0.05).
FCR, feed conversion rate

Data analysis

The standard procedure of Analysis of Variance (ANOVA) was used for the analysis of collected data using completely randomized design (CRD) as suggested by Steel and Torrie (1981) and Fisher LSD for significance difference. P values less than 0.05 were statistically considered significant.

RESULTS

Mean feed intake, weight gain, FCR and dressing percentage are given in Table I. Feed intake was significantly (P<0.05) low and weight gain and dressing percentage was significantly (P<0.05) higher in the OA-2 group, resultantly, the best FCR was recorded in the same group.

Mean gizzard, liver, heart and mortality percentage is given in Table II. No significant difference was found in these parameters between the control and treated groups. Tibia dry matter, ash, calcium (Ca), phosphorus (P), fecal Ca and P of broiler chicks supplemented with OA blend is given in Table III. Tibia dry matter, ash, Ca and P were significantly (P<0.05) higher in OA-2. On the other hand, fecal Ca and P decreased significantly (P<0.05) in OA-2.

Mean nutrient digestibility in broiler chicks supplemented with OA blend is given in Table IV. Mean dry matter and ash contents increased significantly (P<0.05) in OA-2, while crude protein, crude fibre, ether extract and metabolizable energy increased significantly (P<0.05) in OA-1.5 and OA-2.

Table II.- Effect of organic acid (OA) on mean weight of gizzard, liver, heart and mortality percentage of broiler during starter phase.

Group	n	Gizzard (g)	Liver (g)	Heart (g)	Mortality (%)
Control	3	38.36±0.41	54.49±1.21	10.81±0.16	6.66±3.33
OA-0.5	3	38.98±0.66	55.21±0.62	10.95±0.18	6.66±3.33
OA-1	3	39.24±0.40	55.76±1.25	11.12±0.12	6.66±3.33
OA-1.5	3	39.40±0.37	56.72±0.79	11.24±0.19	3.33±3.33
OA-2	3	39.74±0.76	58.26±1.14	11.40±0.26	3.33±3.33
P-Value	3	0.509	0.195	0.318	0.871

Mean values within a column differ significantly (P<0.05)

Table III.- Effect of OA blend (aciflex) on tibia dry matter, ash, calcium, phosphorus, fecal calcium and phosphorus of broiler chicks.

Group	n	TDM	TASH	TCAL	T PHOS	FCAL	FPHOS
OA-0	3	96.25±3.45^{c}	47.90±2.11^{a}	0.78±4.22^{b}	8.15±0.44^{bc}	0.85±0.19^{a}	9.74±0.14^{a}
OA-0.5	3	96.41±1.45^{c}	47.57±1.76^{a}	0.35±1.45^{a}	9.91±0.12^{ab}	0.79±0.18^{b}	7.66±0.15^{ab}
OA-1	3	96.65±6.8^{b}	51.56±1.44^{a}	1.55±2.77^{a}	6.94±0.21^{c}	0.71±0.12^{c}	5.04±0.19^{b}
OA-1.5	3	97.15±4.52^{ab}	48.25±3.77^{a}	1.52±1.66^{a}	9.53±0.87^{ab}	0.67±0.11^{d}	6.46±0.17^{ab}
OA-2.0	3	97.74±5.42^{a}	49.26±2.11^{a}	1.43±1.55^{a}	11.53±0.11^{a}	0.56±0.18^{e}	5.87±02^{b}

Mean values within a column differ significantly (P<0.05). TDM, tibial dry matter; TASH, tibial ash; TCAL, tibial calcium; TPHOS, tibial phosphorous; FCAL, fecal calcium; FPHOS, fecal phosphorous.

Table IV.- Effect of OA blend (aciflex) on mean nutrients digestibility in broiler chicks.

Group	n	DM	ASH	CP	CF	EE	ME
OA-0	3	66.82±0.50^{d}	46.10±0.73^{d}	52.14±1.63^{c}	17.29±0.54^{c}	58.06±1.18^{c}	2307.7±16.8^{c}
OA-0.5	3	69.95±1.08^{c}	50.63±1.72^{c}	54.72±1.19^{bc}	18.06±0.66^{c}	59.48±0.25^{bc}	2355.5±34.6^{c}
OA-1	3	70.76±0.63^{c}	52.99±0.42^{bc}	59.45±0.83^{ab}	20.85±0.67^{b}	61.60±0.34^{b}	2468.9±24.1^{b}
OA-1.5	3	73.52±1.16^{b}	55.88±0.70^{ab}	65.39±3.35^{a}	23.95±0.75^{a}	64.49±0.96^{a}	2584.6±34.7^{a}
OA-2.0	3	76.24±0.58^{a}	57.03±0.85^{a}	66.26±3.09^{a}	24.57±0.28^{a}	64.87±0.47^{a}	2637.7±4.08^{a}

Mean values within a column differ significantly (P<0.05); DM, dry matter; ASH, ash; CF, crude fibre; CP, crude protein; EE, ether extract; ME, metabolizable energy.

DISCUSSION

In the present study, feed intake, weight gain and FCR were improved by the supplementation of OA in broiler. OA tends to increase proteolysis action and leads to improved protein digestibility (Samanta *et al*., 2010). It was found that pH of the GIT is lowered by the OA and utilize the nutrients better (Pakhira and Samanta, 2006). The findings of the current study are in line with the results of the previous studies (Chaveerach *et al*., 2004; Samanta *et al*., 2010). The growth promoting effects of OAs were linked to their ability to control the growth of potential pathogens in the gastrointestinal tract of animals (Hadorn *et al*., 2001). Thus, the digestive tract remains healthy, functions more efficiently and leads to more efficient absorption of nutrients. OAs improve energy and protein digestibility by decreasing microbial load and decreasing subclinical infection (Dibner and Buttin, 2002). *E. coli* and other harmful bacteria are decreased by OAs, which enhance the growth of the poultry birds (Samanta *et al*., 2010). Inside the body, it also produces an acidic environment which causes more availability of the nutrients which results in better performance of the birds (Boling *et al*., 2001). Denli *et al*. (2003) noted that intestinal cell proliferation was caused by different OA and therefore for absorption, more nutrients are available. Samanta *et al*. (2010) showed that the nutrient availability is increased by the acidic condition which results in better performance. The non significant effect of the supplementation of OA in broiler in the present study on the weight of liver, heart and gizzard is in agreement with Denli *et al*. (2003), Cakir *et al*. (2008) and Adil *et al*. (2010).

Our findings of digestibility of nutrients are in agreement with Boling *et al*. (2001) who reported higher values of total digestible nutrients in the diet supplemented with OA. Ao *et al*. (2009) reported that the digestibility of DM and CP increases with citric acid.

According to Onyango *et al*. (2003), in poultry, to assess response of P availability, tibia ash is considered to be the most sensitive criterion. In our experiment, when corn soyabean meal diet having a P deficiency was supplemented with an OA, did not affect the tibia ash. The results indicated that supplementation of OA in a diet lowered in phosphorous content does not increase the tibial ash percentage. Liem *et al*. (2008) reported that when a diet deficient in P content is fed to broiler birds, the tibial ash increased when supplemented with citric, malic or fumaric acid. Our findings are in line with Nezhad *et al*. (2008) who reported that in laying hens, citric acid has a beneficial effect on tibia bone mineralization.

Our results are in contrast with Sacakli *et al*. (2006) who reported that in quails when a diet deficient in phosphorus content is supplemented with OA (formic + lactic, 2.5 g/kg of diet), the tibial ash was increased. This positive effect of OA may probably be attributed to an increased availability of calcium and phosphorus (Hernandez *et al*., 2006; Garcia *et al*., 2007). It has been observed that OA causes improvement of Ca availability by competitive chelating of Ca and a reduction in the formation of insoluble Ca-phytase-complexes (Boling *et al*., 2001).

CONCLUSION

Supplementation of OA at the rate of 2ml/L improved weight gain, feed efficiency, nutrient digestibility and enhanced mineralization of calcium and phosphorus in the tibia in broiler.

Statement of conflict of interest

Authors have declared no conflict of interest.

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